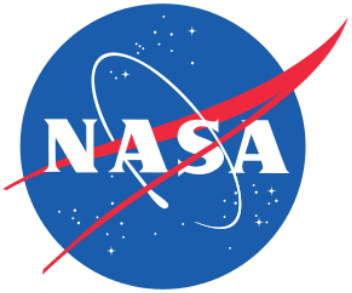

THE CERES S'COOL PROJECT: ANALYSIS UPDATE

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Mentor: Kristopher Bedka, NASA LaRC

ATMOSPHERIC SCIENCES
TEXAS A&M UNIVERSITY

The S'COOL Team

- Lin Chambers – Lead
- Sarah Crecelius – Project Coordinator
- Preston Lewis – Project Coordinator
- Tina Rogerson – Web & Database Developer

NASA's Educational Objective

"inspire and motivate students to pursue careers in science, technology, engineering, and mathematics (STEM)."

Earth Science Strategic Plan

"foster the development of an informed and environmentally aware public."

S'COOL Societal Benefits

- Educational and Public Outreach arm of CERES
- Brings authentic science into K-12 classrooms
- Global wide education on clouds and the environment
- Offers a unique source of validation for CERES cloud retrievals

http://scool.larc.nasa.gov

The S'COOL Project

- Ground-based validation of CERES
- Students make a cloud observation within +/- 15 minutes of a CERES overpass
- Observed cloud properties include: cloud coverage, height, layering, type, and visual opacity
- All observations are compared to CERES Ed. 2 cloud retrievals via FLASHFlux

Why Ground Observers?

Advantage Over Satellites

- Ground observers can observe lower level clouds which may be obscured from a satellite's view by thick upper level clouds
- Humans have a higher spatial resolution than a satellite and have a greater ability to detect small or thin clouds

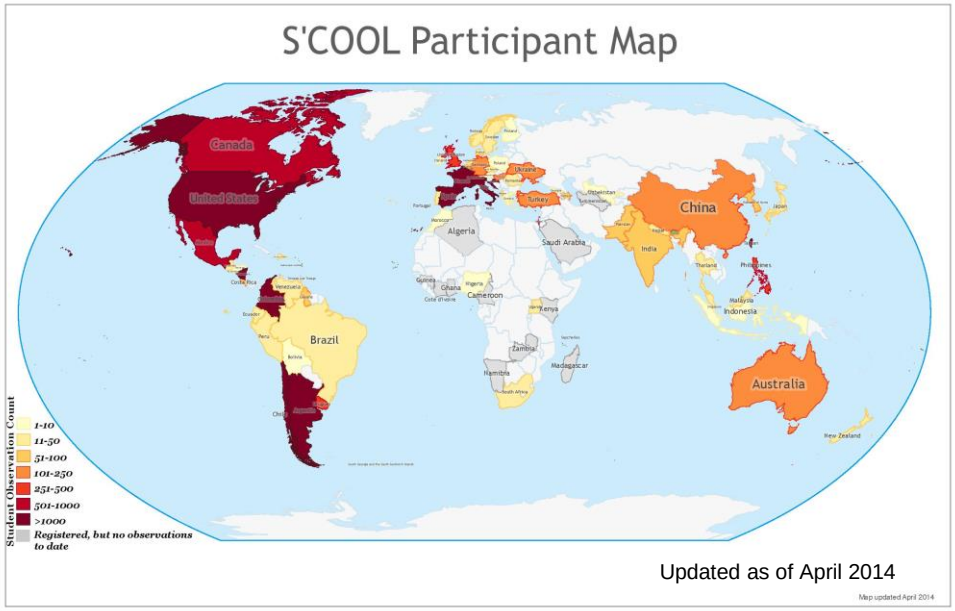
Advantage Over Fixed Ground Sites

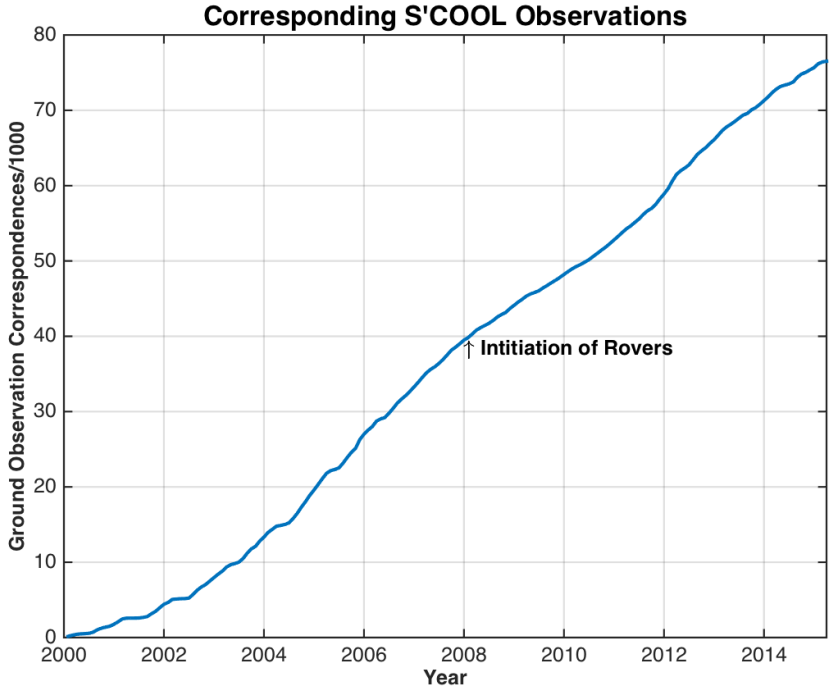
- Ground observers are located across the world, while fixed sites are limited to their spatial extent
- Collected data has to be manipulated and interpreted, while humans can provide the best representation of the cloud scene

Disadvantages of Ground Observers

- View is limited by any obstructions such as buildings or thick low level clouds
- Difficult to discern cloud height by eye
- Mischaracterization of cloud phenomenon (ex. Classifying haze as cirrus)

A Growing Community of Cloud Observers



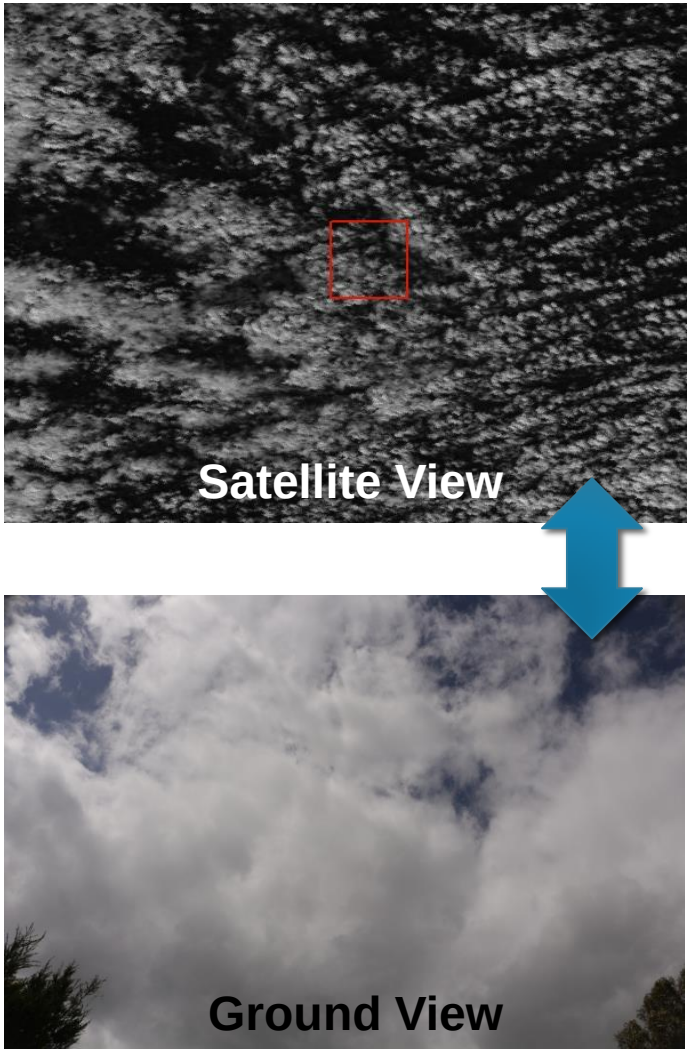


- 1,023 reporting schools and 357 reporting Rovers
- Observing from 64 countries and all 50 states
- Over 76,000 observations matched to satellite overpasses

Cloud Presence Validation

How well do the ground observers and the satellite agree on the presence of clouds?

		GROUND	
		Clear	Cloudy
SAT	Clear	8099	2407
	Cloudy	6901	55094

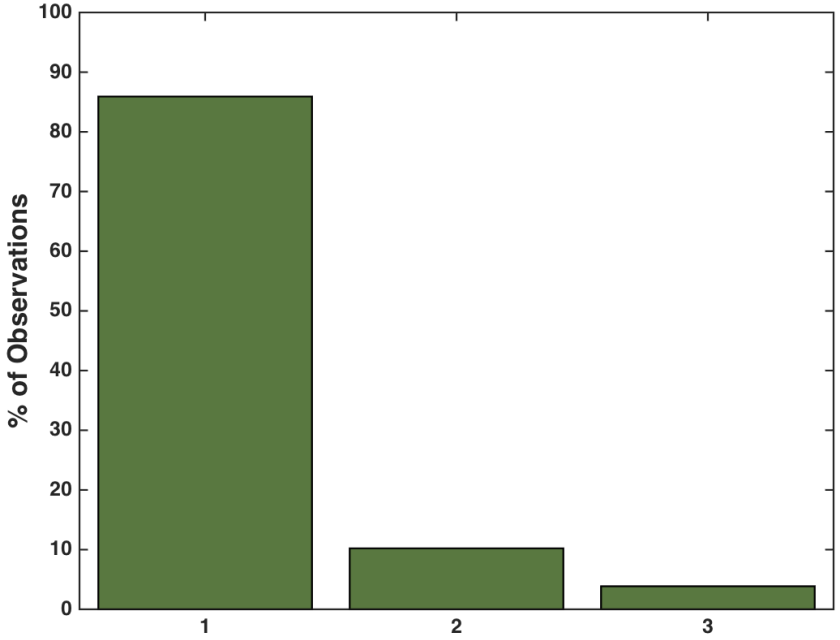


- 87.2% agreement between ground reports and satellite cloud detection
- Comparatively, CERES Ed. 4 cloud mask matched to CALIPSO data has an agreement of 88.5%
- 85.0% agreement on the presence of clouds in snow-covered scenes vs. 87.5% for snow-free scenes

Characteristics of Undetected Cloud Scenes

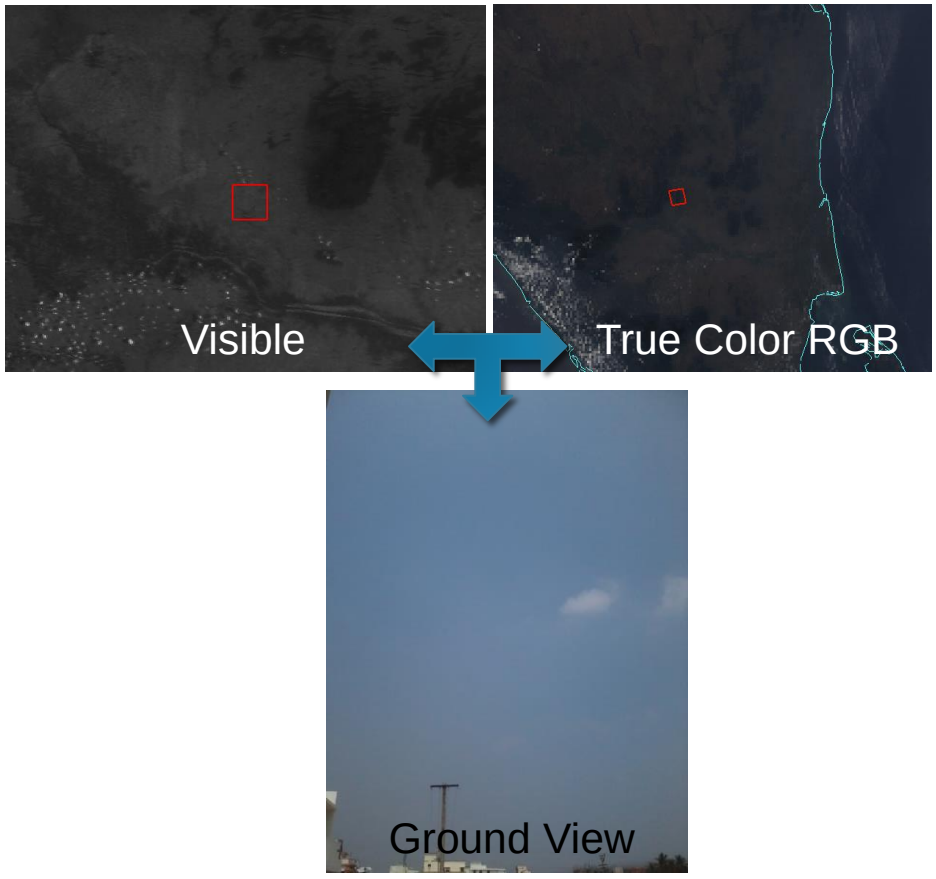
		GROUND	
		Clear	Cloudy
SAT	Clear	8099	2407
	Cloudy	6901	55094

Number of Observed Cloud Layers Missed by CERES Cloud Mask



- Of the clouds scenes missed by CERES cloud mask, 86% of them were single layer
- Some of the missed three cloud layers were due to mischaracterization of cloud scenes

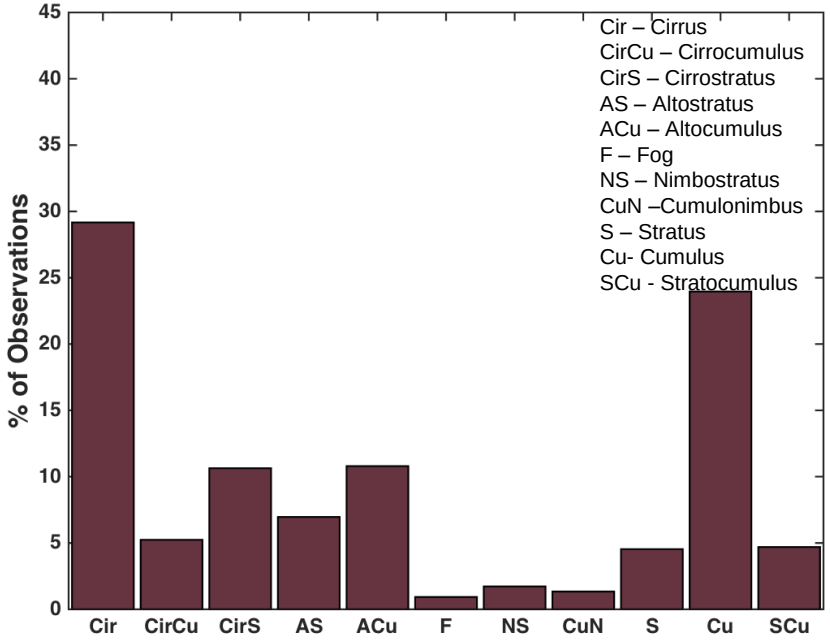
Example Case:
1 layer cloud missed by CERES cloud mask



Characteristics of Undetected Cloud Scenes

		GROUND	
		Clear	Cloudy
SAT	Clear	8099	2407
	Cloudy	6901	55094

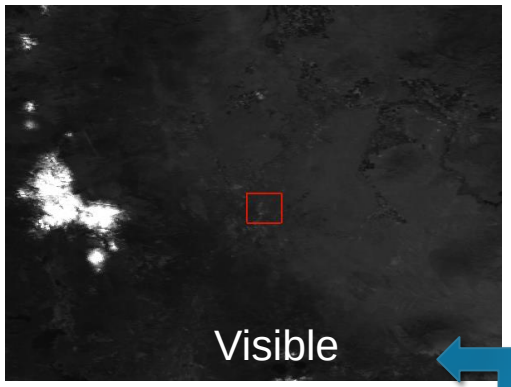
Observed Cloud Types
Missed by CERES Cloud Mask

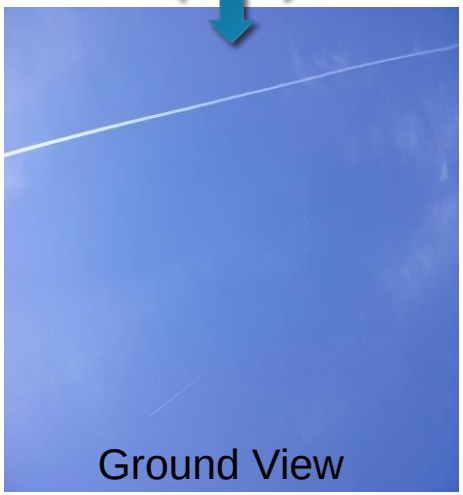


- Most missed clouds by CERES were cirrus and cumulus
- 45% were cirrus type clouds

Example Case:

Cirrus clouds missed by CERES cloud mask





Cloud Cover Comparisons

SAT \ GROUND	Clear (0-5%)	Partly (5-50%)	Mostly (50-95%)	Overcast (95-100%)
Clear (0-5%)	8099	1833	361	213
Partly (5-50%)	5118	9562	4864	1684
Mostly (50-95%)	1360	7221	9208	9656
Overcast (95-100%)	423	1652	3049	8198

Case:	**Counts:**	**Percentage:**	
Agree	35067	48.37%	92.15%
1 – Class Error	31740	43.78%	
2 – Class Error	5057	6.98%	
3 – Class Error	636	0.88%	

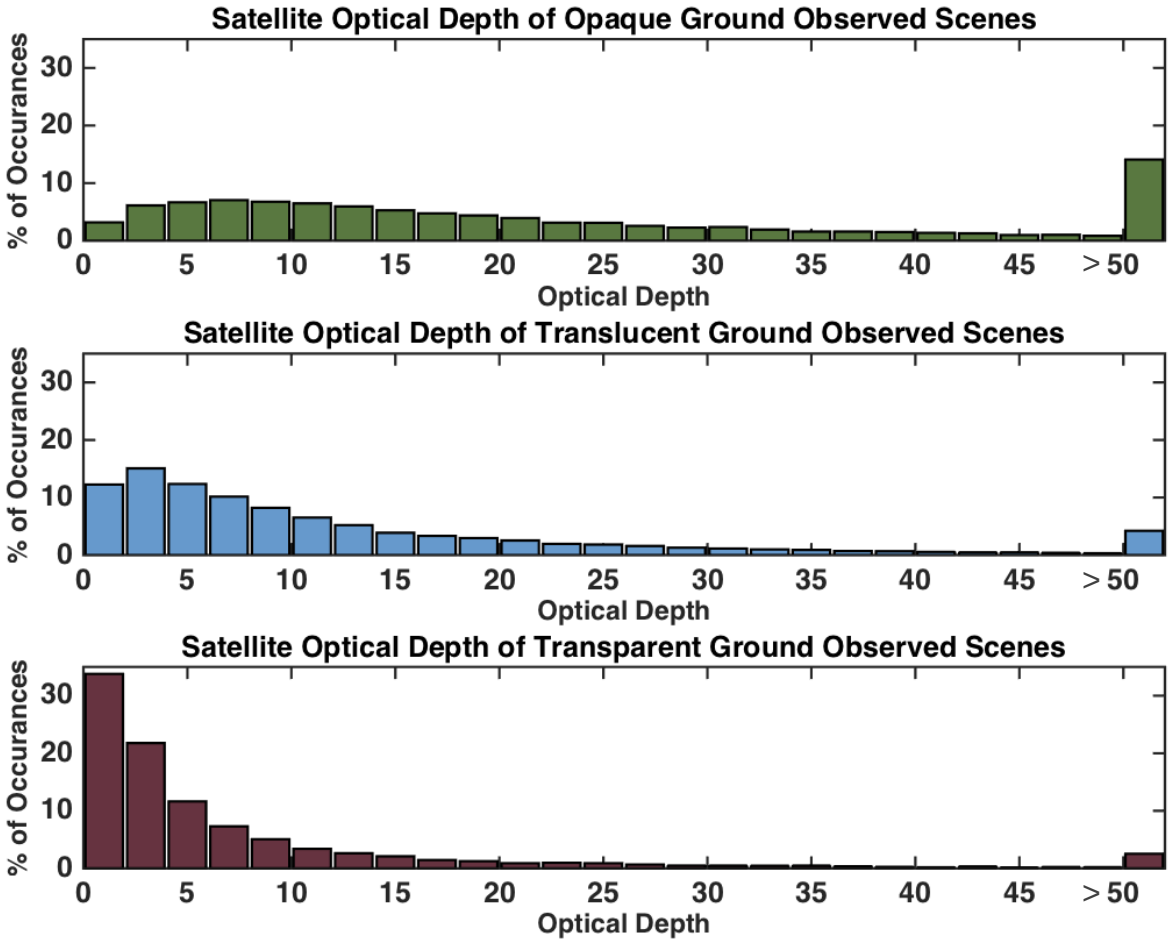
Cloud Layer Comparisons

SAT \ GROUND	No Clouds	Single-Layer	Multi-Layered
No Clouds	8099	2068	339
Single-Layer	4460	19061	6682
Multi-Layered	2441	18704	10647

Case:	Counts:	Percentage:	
Agreement	37807	52.15%	96.17%
1 – Class Error	31914	44.02%	
2 – Class Error	2780	3.83%	

Cloud Opacity Verification

- Histograms of satellite derived optical depth as a function of each ground observed cloud opacity category
- Opaque scenes more commonly correspond to greater satellite-retrieved optical depths
- Transparent scenes have the highest frequency of low optical depths

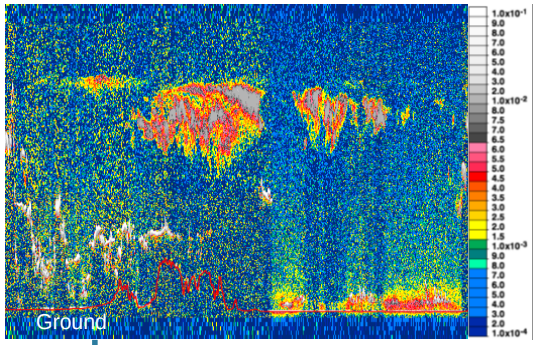


**All values greater than 50 are summed into the last column

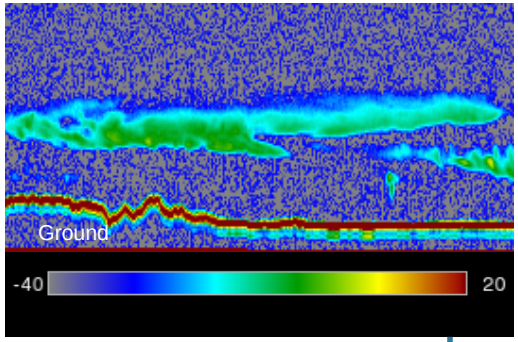
CALIPSO/CloudSat Comparisons

- Active instrumentation onboard CALIPSO and CloudSat can image the cloud ‘truth’
- Can compare cloud layering and cloud height to S’COOL observations
- Serve to verify the S’COOL observations or highlight their areas of weakness
- Most useful at validating cloud cover and cloud layers

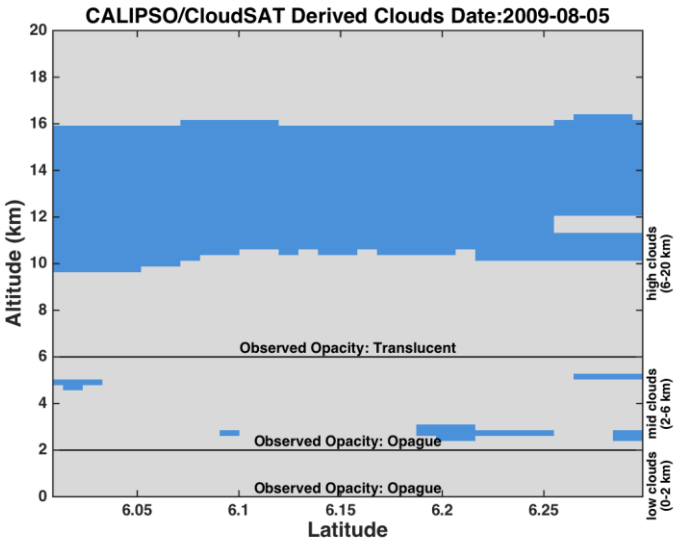
CALIPSO Total Attenuated Backscatter



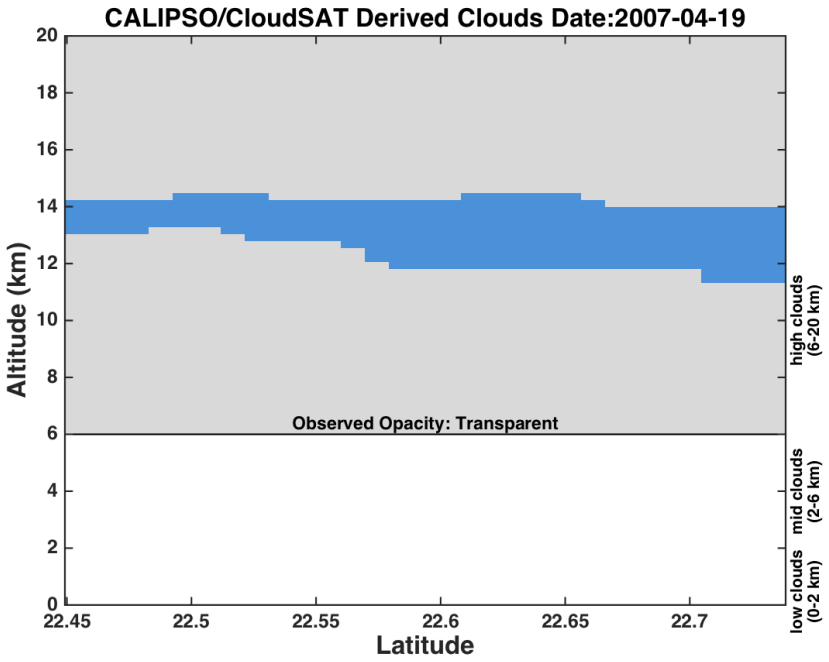
CloudSat Radar Reflectivity

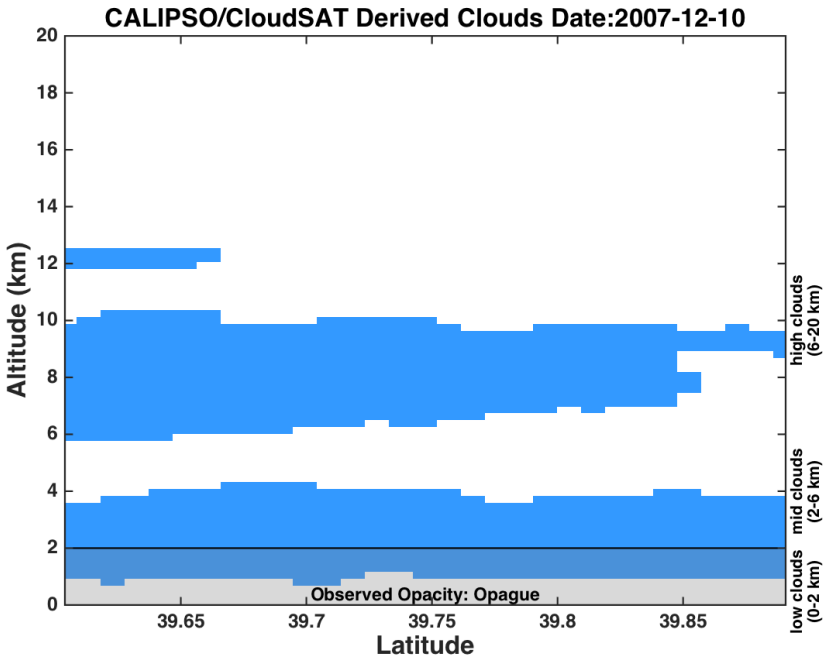


CALIPSO + CloudSat Over a S’COOL Observation Site



CALIPSO/CloudSat Comparisons





- Confirms that the ground observer correctly identified the number of cloud layers and cloud height
- Demonstrates how a ground-observers' view of any upper level clouds can be obscured by opaque lower level clouds

S'COOL Accuracy to Other Observers

Rovers

- Citizen Scientists are an additional part of the S'COOL Project, who report from permanent to non-permanent locations
- Have the same observation protocol as S'COOL observers

GLOBE

- Another community of ground-based cloud observers
- Report total cloud coverage, the presence of individual cloud types, and many other parameters (T, wind, etc..) near solar noon

	Total Matches	Cloud Presence Accuracy	Cloud Cover Agreement	Cloud Layers Agreement
S'COOL	72,501	87.16%	48.37%	52.15%
Rovers	4,036	86.87%	48.17%	43.71%
GLOBE	9,839	81.13%	38.07%	45.39%

Summary

- Given the comparable agreement between the ground and satellite platforms, ground observers offer a reliable source of cloud detection
- Able to determine that cirrus and small clouds are a challenge for CERES cloud detection algorithms from ground observations
- Detection of cloud coverage and cloud layering is reliable given the clouds have sufficient breaks for observers to see through
- Matching ground observations with CALIPSO and CloudSat gives us new insight into S'COOL observations

Future Work

- Compare available S'COOL observations to CERES Ed. 4
- Integration of geostationary cloud products into comparisons
- Further refine the CALIPSO/CloudSat comparisons to S'COOL observations product

Acknowledgments

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